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# LONG-TERM MONITORING OF BRIGHT BLAZARS WITH A DEDICATED CHERENKOV TELESCOPE

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Flaring activity of Active Galactic Nuclei (AGN) in VHE $\gamma$-ray astronomy is observed on timescales from minutes to years and can be explained either by the interaction of relativistic jets with the surrounding material or by imprints of the central engine, like temporal modulation caused by binary systems of supermassive black holes. The key to answer those questions lies in combining 24/7 monitoring with short high sensitivity exposures as provided by the third generation $\gamma$-ray astronomy instruments like MAGIC, VERITAS and H.E.S.S. The long-term observations can be provided by a global network of small robotic Cherenkov telescopes[1]. As a first step, we are currently setting up a dedicated Cherenkov telescope, which will carry out joint observations with the Whipple 10 m telescope for AGN monitoring. The new telescope will be designed for low costs but high performance by upgrading one of the former HEGRA telescopes, still located at the MAGIC site on the Canary Island of La Palma (Spain). The main novelties will be its robotic operation and a novel camera type, resulting in a greatly improved sensitivity and a lower energy threshold.

*Keywords*: Keyword1; keyword2; keyword3.

## 1. Introduction

Since the termination of the HEGRA observations, the succeeding experiments MAGIC[2] and H.E.S.S.[3], along with VERITAS[4] and CANGAROO[5], have impressively extended the physical scope of $\gamma$-ray astronomy by significantly lowering the energy threshold and increasing the sensitivity. To fully exploit this potential, the discovery of new, faint objects has become the major task for the new telescopes, which limits their availability for monitoring purposes of well-known bright sources. There are, however, strong reasons to make an effort for the continuous monitoring of the few exceptionally bright blazars. This can be achieved by operating a dedicated monitoring telescope, referred to in the following as DWARF (**D**edicated multi**W**avelength **A**gn **R**esearch **F**acility).

## 2. Science case

The variability of blazars, seen across the entire electromagnetic spectrum, arises from the dynamics of relativistic jets which are launched in the vicinity of accreting supermassive black holes. Theoretical models predict variability arising from the interplay between jet expansion, particle injection, acceleration and cooling[6].
To overcome the limitations of biased sampling, a complete monitoring database of a few representative bright sources needs to be built up. DWARF will run as a facility dedicated to long-term monitoring of few selected blazars only: Mrk 421, Mrk 501, 1 ES 2344+514, 1 ES 1959+650, H 1426+428, PKS 2155-304, of which at least one will be visible any time of the year. The following investigations are planned:

- The duty cycle, the baseline emission, and the power spectrum of flux variations will be determined and compared to those in other wavebands.
- The black hole mass and accretion rate will be determined from emission models based on the obtained lightcurves and compared to estimates from a possible orbital modulation, and the Magorrian relation[7].
- When flaring states appear during the monitor program, MAGIC will issue a Target of Opportunity observation to obtain better time resolution.
- Correlating the arrival times of neutrinos detected by IceCube with simultaneous measurements of DWARF will allow to test the hypothesis of hadronic emission processes leading to neutrino emission from these sources[8,9]. This investigation is complete for both neutrino and $\gamma$-observations, and can therefore lead to conclusive results.
- Multi-frequency observations together with the Metshovi Radio Observatory and the optical Tuorla Observatory are planned. The measurements will be correlated with INTEGRAL and GLAST results.
- The most ambitious goal of this project is the search for signatures of binary black hole systems from orbital modulation of VHE $\gamma$-ray emission[10,11].

Furthermore, a robotic telescope is an essential contribution to the next plans in $\gamma$-ray astronomy like a global monitoring array or a single location array like CTA[12].

## 3. Technical setup

The former HEGRA telescope CT3 at the Oberservatorio del Roque de los Muchachos (ORM) will be refurbished and equipped for robotic operation to reduce costs and man power demands.

**Drive system** The drive system should allow for relatively fast repositioning to ensure good time coverage during wobble-mode observations and observations of more than one source visible at the same time. Therefore three 150 Watt servo motors and a microcontroller based motion control unit (SPS), similar to the one of the current MAGIC II drive system[13], will be used.

**Mirrors** The existing mirrors are replaced by new plastic mirrors. The cheap and light-weight material has formerly been used for Winston cones flown in balloon experiments. The mirrors are copied from a master and coated with a reflecting and a protective material. By a change of the mirror geometry the mirror area can be increased from $8.5\,\mathrm{m}^2$ to $13\,\mathrm{m}^2$; this includes an increase of ∼10% per mirror by using a hexagonal layout.

**Camera** A camera with a FoV of about 3.5°-5° allows $n \geq 2$ independent positions for background estimation in wobble-mode and by this increases sensitivity by a factor of $\sqrt{2\sqrt{n}}$. To decrease the dependence of the measurement on the camera geometry, a round camera layout will be chosen.
As focal plane instrumentation a novel camera based on Geigermode Avalanche Photo Diodes (G-APDs, also known as SiPMs or MPPCs) that is currently developed will be used. G-APDs promise a highly enhanced photon detection efficiency compared to PMTs, which lowers the achievable energy threshold for a given mirror area. In addition, they have practical advantages including a lower bias voltage and insensitivity to accidental exposure to light. Tests leading to the first detection of Cherenkov light from air showers are presented in Ref. 14. The G-APD type selected for the camera project (Hamamatsu MPPC S10362-33-100C[15]) has a dimension of $3{\times}3\,\mathrm{mm}^2$. Four G-APDs will be added linearly forming a "pixel". For further details see Ref. 16.

**Camera support** Each individual G-APD will be equipped with light collector (modified Winston cone) to increase the light collection area. Their light-collection efficiency will either be improved by using a highly reflecting (∼ 98%) mirror-foil, or by using solid glass cones utilizing total reflectance.

**Data acquisition** The data acquisition system (DAQ) will be based on an analog sampling chip (DRS2/DRS4, developed at PSI[17]), like the DAQ currently designed for MAGIC II[18]. This allows to include the digitization within the camera which makes an analog signal transfer obsolete. By high sampling rates ($\geq 2\,\mathrm{GHz}$), the over-all sensitivity will be increased further due to almost perfect suppression of

night-sky background photons[19]. The available automatic analysis package developed for MAGIC is modular and flexible[20], and can thus be used with minor changes for DWARF.

## 4. Future extensions

A telescope at a single location substantially limits the time-coverage of observations. Therefore we propose a future global network of ($< 10$) Cherenkov telescopes: A system so far unique in this energy range, which will allow 24 h monitoring of bright Blazars. The approved cooperation with the Whipple 10 m-telescope is the first step in this direction.

## 5. Conclusion

The setup of a small telescope dedicated for long-term AGN monitoring is easily feasible. Such an activity is motivated by a variety of physical questions to be answered by the integration of this instrument in multiwavelength observations.

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